

## Studies on the Influence of Water Quality on Periphyton and Benthic Fauna along the River Gora A Tributary of Blue Nile, Ethiopia

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### Abstract

The water quality in relation to benthic macroinvertebrates and periphyton of River Gora, a tributary of Blue Nile during the dry season (December 2015 to February 2017) was studied at Jeldu district in Ethiopia. The water flow rate fluctuated from 0.32 to 0.6 m<sup>3</sup>/sec. The water temperature did not vary considerably and pH was slightly alkaline. The mean dissolved oxygen varied from 5.5 mg/l and 11.12 mg/l and water hardness ranged from 608 to 640 mg/l. The mean values of total nitrate and phosphorus contents were 0.38 and 0.52 mg/l and 1.35 and 6.58 mg/l respectively. The organic carbon and organic matter of the bottom soil varied considerably in February. The diatoms dominated in terms of species as well as population density among the periphyton while the members of the order Diptera was the most abundant benthic invertebrate group. The variations in the biotic components with respect to water quality were also discussed.

**Keywords:** Periphyton; Macroinvertebrates; Soil organic carbon; Organic matter

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### Introduction

Rivers play significant roles in the provision of water for domestic and industrial purposes. Nevertheless, land use dynamics continue to impact on river catchments which have negative repercussions for river health. Aquatic organisms are often considered as engineers' of aquatic ecosystems, play a vital role in the nutrient cycle [1] and also serve as useful protein materials for fish and shellfish [2]. The periphyton community is the slimy coating that adheres to rocks and other stable substrates that comprise of variable proportions of algae, fungi and bacteria as well as organic matter entrained from stream flow. In fast-flowing, oligotrophic lotic habitats, attached algal communities (periphyton) are often the only primary producers, play an important role in the food web through the transformation of energy [3]. Periphyton communities have been used as biotic indicators of ecological condition and change in response to human and natural disturbances [4]. Similarly the benthic invertebrates are important in moving energy through food webs which usually inhabit bottom substrates for at least part their life cycle [5]. These organisms are differentially sensitive to many biotic and abiotic factors in their environment [6]. Among these insects [7] are more diverse in lotic systems. It is stated that less than 3% of all species of insects begin their life cycle as aquatic larvae before emerging as adults [8]. Several studies have been undertaken to understand the streams and rivers with

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respect to periphyton and benthos in Ethiopia [9,10]. The Gora River is one of the tributaries of Blue Nile, supports the livelihood and water requirements of a large number of people and hence it is crucial to assess the water quality using biotic indicator communities which is comparatively rapid and reliable method. The present study mainly emphasizes the composition and distribution of periphyton and benthic invertebrates with respect to water quality parameters and nature of bottom substratum in the River Gora.

### Materials and Methods

Three stations were selected along the course of Gora River at Jeldu district, Ethiopia for the present study. Station 1 is located between 03°90'619" N and 10°32'571"E, Station 2 between 03°91'192" N and 10°33'030 E and Station 3 between 03°89'958"N and 10°33'283"E. Water temperature and pH were measured in the field by using digital probes after making standard calibrations. The dissolved oxygen and total hardness of the water samples were estimated by Winkler's Azide and EDTA methods respectively [11]. Nitrate and phosphate were estimated as described by EPA (12) and Olsen., *et al.* [13]. The river flow velocity was measured by float method [14]. The soil organic carbon and organic matter were estimated by Walkley and Black method [15]. Periphyton and benthic fauna samples were collected during December 2015- April 2016 by using quadrat method. All benthic samples were sieved through 200-500 µm seive and fixed in 5% formaldehyde for further identification. The qualitative and quantitative analyses were done as described by Arbačiauskas., *et al.* [16]. For the periphyton, the organisms attached to submerged stones, rocks and wood logs were collected by scrapping from a unit area and preserved for qualitative and quantitative analyses.

### Results

The water flow rate at all the stations showed decreasing trend from December to February. The maximum flow was recorded in December (0.6 m<sup>3</sup>/sec) at station 1 and minimum (0.32 m<sup>3</sup>/sec) in February at station III [Table1]. The water temperature remained between 20.3 and 20.5°C at all the three stations. The pH of water in Gora River was minimum 7.63, 6.4 and 7.03 and maximum 8.06, 8.23 and 8.15 in station I, II and III respectively.

Parameters	Station I			Station II			Station III		
	Dec	Jan	Feb	Dec	Jan	Feb	Dec	Jan	Feb
Water flow m <sup>3</sup> /sec	0.6	0.54	0.35	0.4	0.35	0.35	0.34	0.32	0.32
Water temperature (°C)	20.5	20.4	20.5	20.4	20.3	20.3	20.5	20.5	20.4
pH of water	8.06	7.63	7.84	8.23	6.44	7.60	8.15	7.04	7.83
DO (mg/l)	5.61	7.07	11.12	6.55	8.08	11.12	5.5	9.09	11.01
NO <sub>3</sub> -N (mg/l)	0.39	0.52	0.44	0.49	0.45	0.38	0.44	0.43	0.44
Phosphate (mg/l)	1.35	1.79	3.37	6.58	4.62	1.54	3.44	2.42	1.69
Hardness (mg/l CaCO <sub>3</sub> )	608	640	629	628	612	625	628	624	612
Soil Organic carbon (%)	0.49	0.49	0.91	1.08	1.09	0.36	0.64	1.27	0.33
Soil Organic matter (%)	0.85	0.83	1.57	1.86	1.96	0.62	1.11	2.20	0.57

**Table 1:** Physico-chemical parameters of water and soil.

The dissolved oxygen increased from December (5.61 mg/l, 6.55 mg/l and 5.5 mg/l) to February (11.12 mg/l, 11.12 mg/l and 11.01 mg/l) at stations I, station II and station III respectively. Total hardness varied between the stations (608 mg/L to 640 mg/L in station I, 612 mg/L to 628 mg/L in station II and III). The nitrate (NO<sub>3</sub>-N) noticeable variations between the sampling months the lowest and highest values (0.38 mg/l and 0.52 mg/l respectively) were observed during different months and 0.44 mg/l in December, January and February respectively. At station II the values showed decreasing trend from 0.49 mg/l (December) to 0.38 mg/l (February). However, the values did not vary at station III and it was 0.44 mg/l, 0.43 mg/l and 0.44 mg/l in December, January and February respectively. The

total phosphorus (TP) concentration in water samples showed increasing trend at station I, the values were 1.35 mg/l, 1.793 mg/l and 3.376 mg/l in December, January and February respectively. However, the values decreased from 6.582 mg/l to 1.54 mg/l (Station II) and 3.439 mg/l to 1.688 mg/l at stations II and III respectively. The amount of organic carbon level in the bottom soil at station I varied from 0.495 % (December) to 0.915 % (February). At station II the values were higher than station I (1.08% 1.09% December and January respectively) and decreased to 0.36% in February. Station III showed much fluctuation and the values were 0.645 % in December, 1.275 in January and 0.33 in February. The organic matter (OM) in the soil was maximum (2.20%) and minimum (0.57 %) in station III. The OM values in station I was 0.83 % in December and January and increased to 1.57 % in February. At station II the values were found to be 1.86 %, 1.96 % and 0.62 % in December, January and February respectively.

### Periphyton

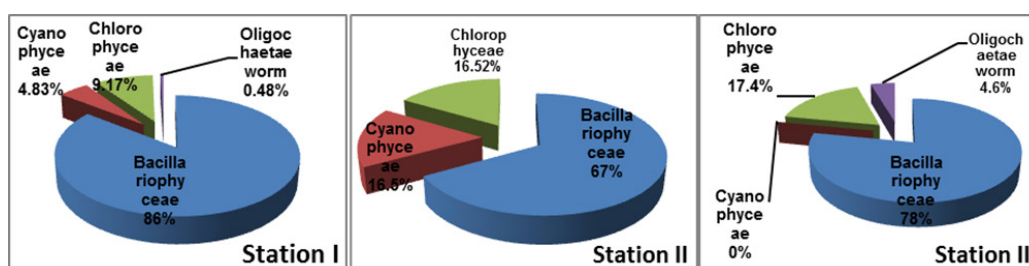


Figure 1: Percentage composition of periphyton in river Gora.

Percentage composition of periphyton population observed in the River Gora is presented in Figure 1. A total of 21 genera belonging to Bacillariophyceae, Cyanophyceae, Chlorophyceae were found along with oligochaete worms. Bacillariophyceae comprised 86% in station I, 67% in Station II and 78% in station III. There were 12 species of diatoms viz., *Pinnularia* sp., *Gomphonopsis* sp., *Navicula* spp., *Nitzschia* sp., *Cyclotella* sp., *Asterionella*, sp., *Cymbella* sp., *Diatoma* sp., *Fragillaria* sp., *Gyrosigma* spp., *Gomphonema* sp., and *Tabellaria* sp. The second most abundant group Chlorophyceae comprised 9.17%, 16.52% and 17.38 % in station I, station II and station III respectively represented by *Actinastrum* sp., *Ankistrodesmus* sp., *Cryptophyta* sp., *Cosmarium* sp., and *Monorophidium* sp. The Cyanophyceae comprised 4.83% and 16.48% respectively in station I and station II represented by *Anabaena* sp., *Oscillatoria* sp., and *Lyngbya* sp. The oligochaetes were found at station I (0.48%) and station III (4.6%).

### Benthic fauna

The benthic invertebrates identified were categorized into Ephemeroptera (May flies), Diptera, Trichoptera (Caddis flies), Odonata (Dragon Flies), Ezygoptera (Damsel flies) and Oligochaeta (worms). Diptera was found to be the most abundant forming 38%, 40.7% and 57 % at stations I, II and III respectively. The Trichopteran species were comprised 21% in station I, 16% in station II and 21% in station III. Ephemeroptera constituted 8%, and 12% at station I and station II respectively, whereas in station III they are absent. Odonata and Ezygoptera were poorly represented. Oligochaeta was the second important group dominant group respectively 28% (station I), 28.3% (station II) and 18% (station III).

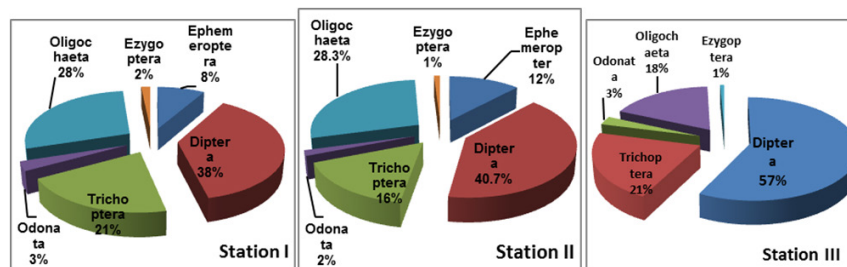


Figure 2: Percentage composition of benthic macro-invertebrates in River Gora.

## **Discussion**

### **Physico-chemical parameters of water**

The rate of river flow during the study period decreased from station I to station III which might be due to the increase in the width of the channel and the presence of more number of deeper pools at station II and III [17]. The flow variability depends on the structural pattern of rivers [18]. Temperature exerts a major influence on biological activity and growth of organisms that can live in rivers and lakes. The temperature in the study site didn't vary considerably and to affect the organisms. Water pH levels play an important role on the health of bodies of water and their ecosystems. pH value in the present study also in the limits [19]. Rapidly moving water, such as mountain streams or a large river, tends to contain a lot of dissolved oxygen. The relatively high level of dissolved oxygen during February is due to the absence of suspended soil particles in the water and exposure to air [20] and the presence of large quantity of filamentous algae and periphyton contribute oxygen through photosynthesis. Bottom feeders need minimal amounts of oxygen (1-6 mg/L) [21]. Based on hardness, water classified into three different categories; soft water (0 to 75 mg/L), moderately hard water (76 to 150 mg/L) and hard water (151 to 300 mg/L) [22]. In the present study the total hardness of the water remains higher. This might be due to the presence of limestone rocks all along the river bed in the study sites and the natural weathering of Ca<sup>+</sup> and Mg<sup>+</sup> rich rocks bordering the river bank [23,24]. The nitrate content in the Gora river water ranged from 0.38 mg/l to 0.52 mg/l. The values are slightly higher in station III where small tributaries join together. This is also related to the disposal of domestic and agricultural wastes containing fertilizers around the river banks [25]. The increase in phosphate value at site1 could be also due to the mineralization of organic matter at the bottom and the weathering of the medium to large size stones at the bottom. The observed values of nitrate and total phosphorous values were within the WHO standards [26]. The stones at site 1 holds large amounts of sediment admixed with particulate materials and algae during the february when the flow rate was reduced. The high rate of decomposition of the settled particulate organic materials could have contributed towards the high rate of organic matter than the other sites.

### **Periphyton composition**

Periphyton is a complex matrix of algae and heterotrophic microbes attached to submerged substrata in all aquatic ecosystems [3]. Excessive periphyton growth can occur in rivers as a result of high water temperature from reduced and managed flows [27]. In the present study relatively more number of genera were represented by Bacillariophyceae and their abundance was also high than those belonging to green and bluegreen algae. This could be due to the presence of high mineral content, temperature and light intensity favouring their rapid multiplication. The higher number of diatom in the periphyton indicates the alteration of pH, liter falls underlying the river bed impacts on the water through the process of decay thereby introducing humic substances [28,29]. Some rivers manifest community structure in patches as well as in continuous patterns, usually one more than the other and the levels of periphyton were highly variable in different zones along streams [30]. Similar results were observed in the distribution of diatoms in the present study. The other groups like Chlorophyceae, Cyanophyceae, and cryptophyceae were found lesser in number due the less adherent character and flow rate of water [30,31].

### **Benthic macro invertebrates**

In the study sites Dipterans were more abundant followed by oligochaete worms, Trichoptera, Ephemeroptera, Odonata and Ezygoptera. The benthic macroinvertebrates respond to fluctuations in the level of dissolved oxygen, pH, and alkalinity [31]. Oligochaeta are aerobic worms which live in soil where more amount of oxygen is available. In the present study the high oxygen content in the water would have influenced the growth of oligochaetes. Generally the chironomids are influenced by water flow, temperature, amount of food and nutrients in the water [32] while the Ephemeropterans are sensitive to environmental perturbations and usually live in clean and well oxygenated waters [33] and their species diversity is influenced by substratum type, riparian vegetation, catchment land use and human activities [34]. Among benthos Caddis fly (Trichoptera) and May fly are less abundant in the river water –soil interface because they tend to prefer specific substratum type in the streams [35]. In the light of the present study, the river Gora at Jeldu district is less polluted and can be recommended for domestic utilization.

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